In-depth Visualization Tutorial

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2006 LCF Users' Meeting

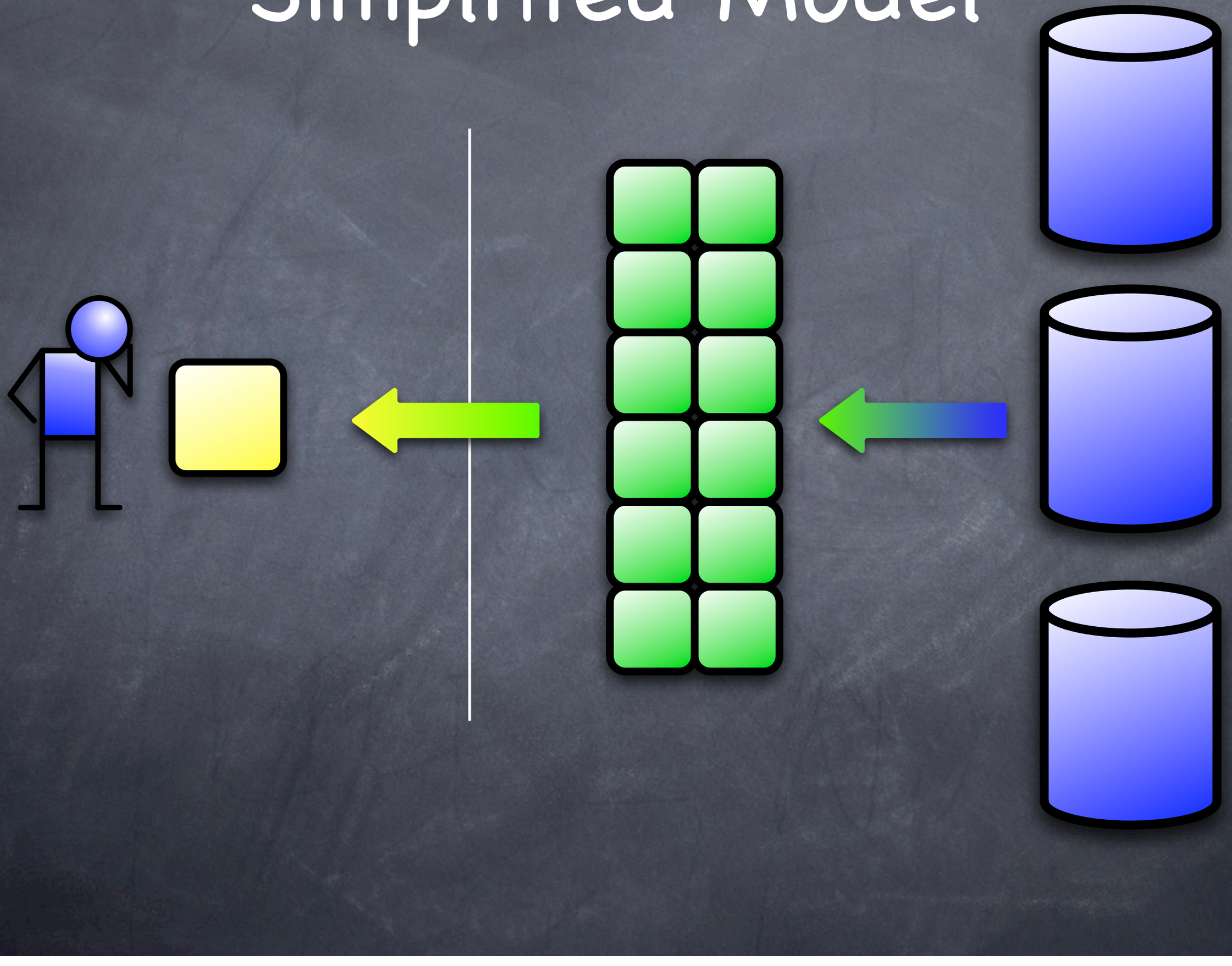
Outline

- Remote Visualization Concepts
- Hardware
- Remote access with tools
  - VisIt
  - Paraview
  - EnSight

Remote Visualization

- Thin client
  - Close to the user, close to graphics card
- Large parallel server
  - Integration with Lustre (soon) for scalable I/O performance
  - Integration with SLURM scheduling system
- Small data stream to the client: geometry or imagery
- Launching and socket initiation
  - Different for each tool!

Simplified Model



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Hawk Visualization Cluster

- Dedicated visualization cluster
- 64 nodes
- Dual opterons, 1.6 MHz
- 128 gigs of memory
- Quadrics Elan3 interconnect
- NVIDIA 5900 and NVIDIA QuadroFX 3000G GPUs
- High-speed connection to 10 GigE infrastructure
- Lustre integration
- 14 nodes "dedicated" to EVEREST
- Firewall exception for hawk.ccs.ornl.gov, providing easy access to parallel vis resource

Access to hawk nodes

- ssh
- hawk0
- SLURM
- VPN, when needed

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Data

The common dataset is from John Blondin (NCState) as part of the Terascale Supernova Initiative. It is a model with a moderate rotation of the infalling gas (spinning about the x axis). The general class of run is described here:

> Recent three-dimensional simulations of core-collapse supernovae have revealed the existence of non-axisymmetric modes of the Spherical Accretion Shock Instability, or SASI. Here we investigate the growth of these modes using two-dimensional simulations of the accretion flow in the equatorial plane of a core-collapse supernova. By perturbing a steady-state model we are able to excite both one- and two-armed spiral modes that grow exponentially with time, demonstrating that these are linearly unstable modes. By tracking the distribution of angular momentum, we demonstrate that these modes are able to efficiently separate the angular momentum of the accretion flow (which maintains a net angular momentum of zero), leading to a gradual spin-up of the underlying accreting proto-neutron star.

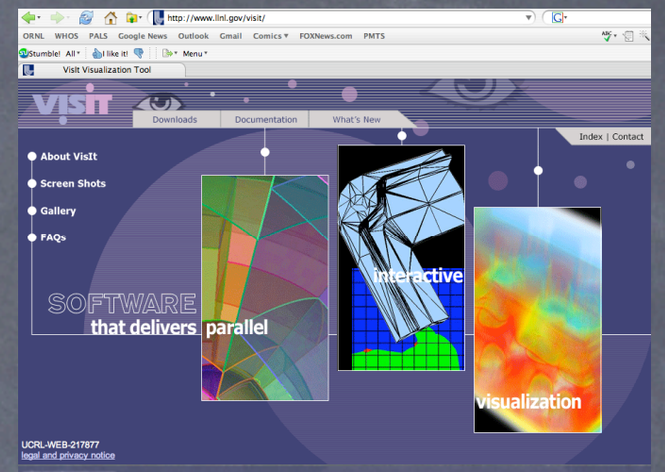
The data is 800^3 uniformly spaced Cartesian grids, with scalars of density, pressure, and a vector of velocity.

Caveats

- This is not a performance "bake-off"
- Vagaries of I/O subsystem, memory footprints, data format, etc.
- This is a demonstration of capability, not performance

VisIt

VisIt

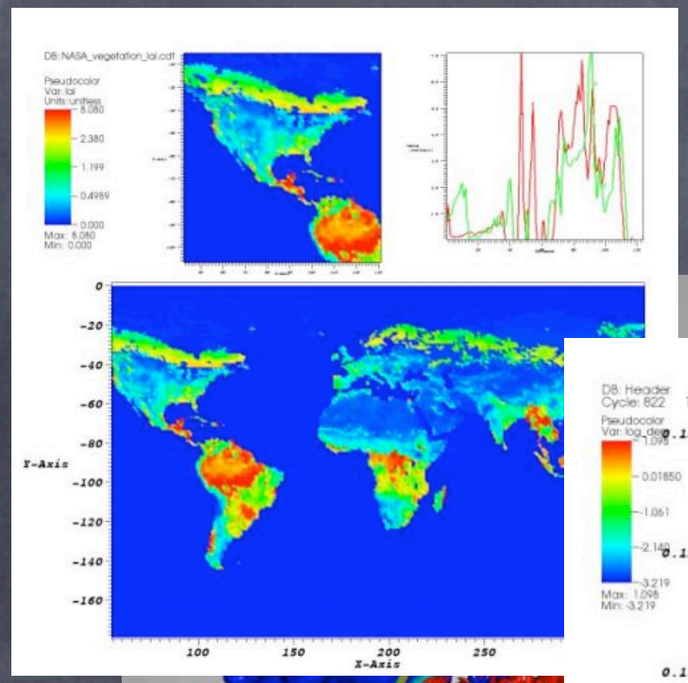


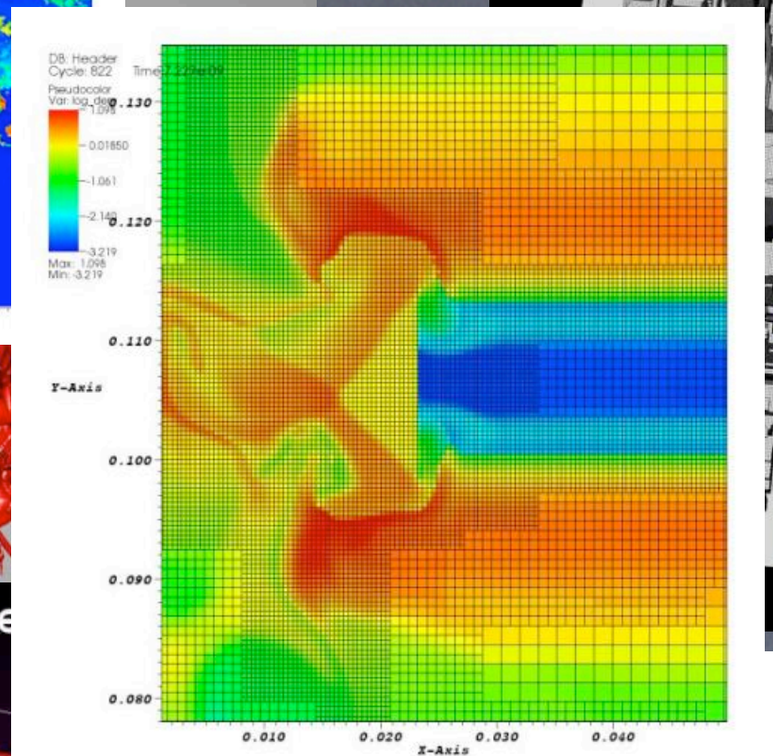
- Open Source, from the DOE ASC program
- Download from http://www.llnl.gov/visit
- Tight integration with job launching system (SLURM, others)
- Rich data model:
  - Structured, unstructured, point, AMR, block-structured, 1D, 2D, 3D, 4D
  - Scalars, vectors, tensors, materials, species
- Many data input formats
- Winner of a 2005 R&D100 Award

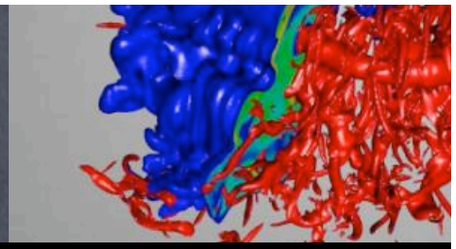
VisIt Technologies

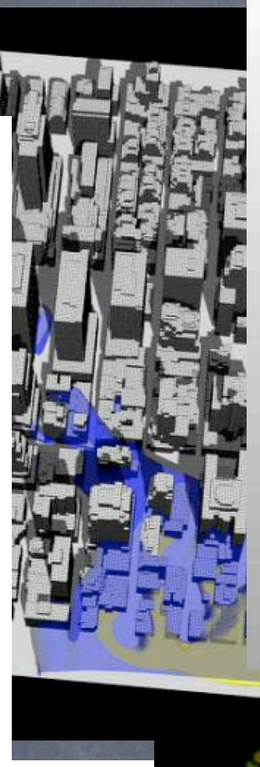
- Uses VTK for much data processing and data model.
- Custom parallel, distributed, networking, rendering, ...
- Written in very modular C++.
- Accessible through GUI, Python, Java

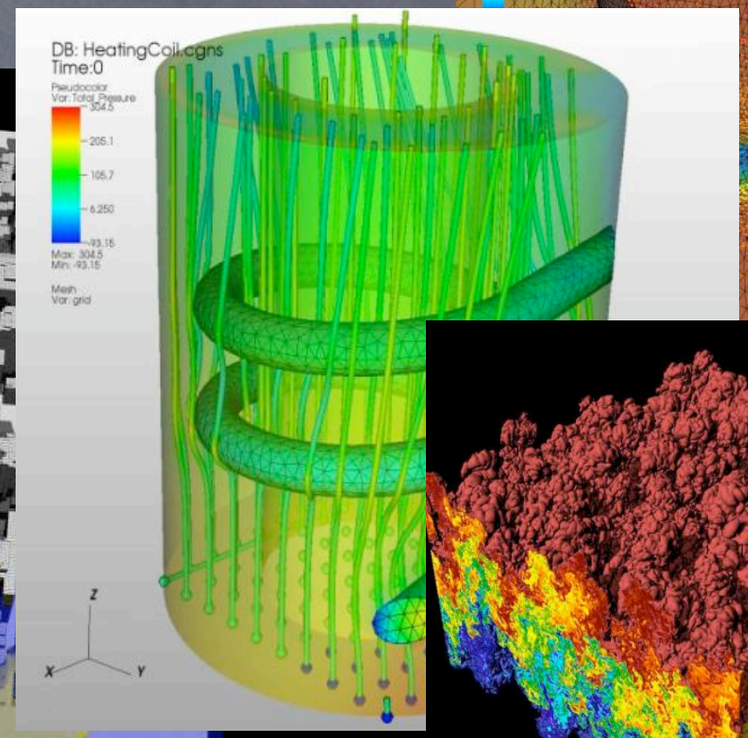
Gallery

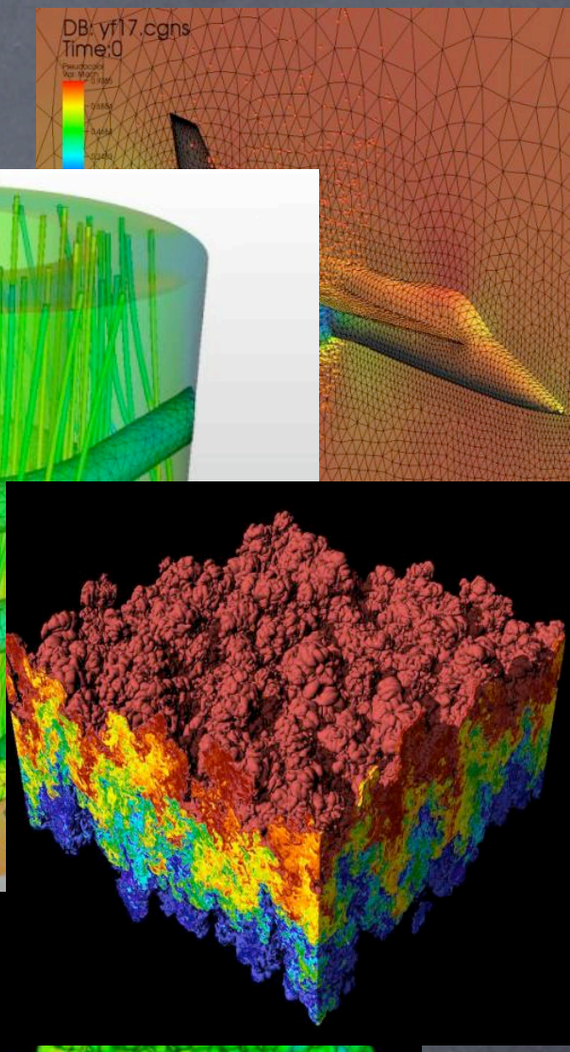

DB: NASA_vegetation_lai.cdf
Pseudocolor
Var: lai
Units: unitless
8.080
2.380
1.199
0.4989
0.000
Max: 8.080
Min: 0.000
0
-20
-40
-60
-80
-100
-120
-140
-160
Y-Axis
100
150
200
250
X-Axis

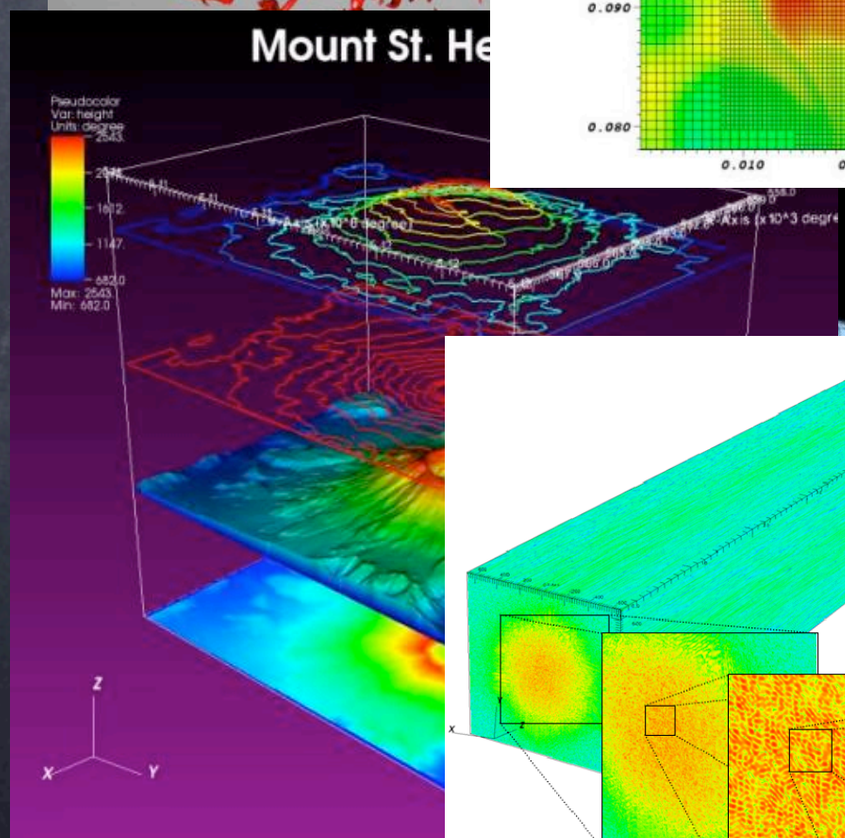

DB: Header
Cycle: 822
Pseudocolor
Var: log_dep
1.098
0.01850
-1.061
-2.142
-3.219
Max: 1.098
Min: -3.219
0.130
0.120
0.110
0.100
0.090
0.080
Y-Axis
0.010
0.020
0.030
0.040
X-Axis

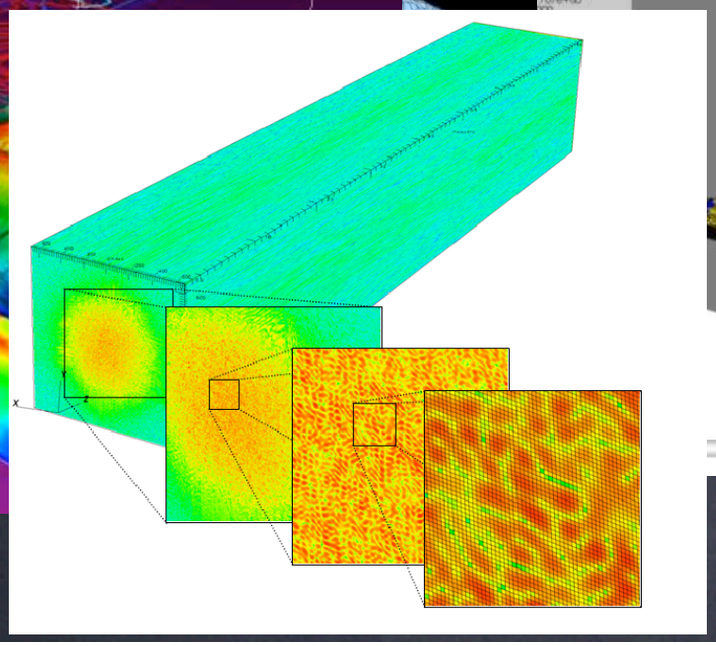


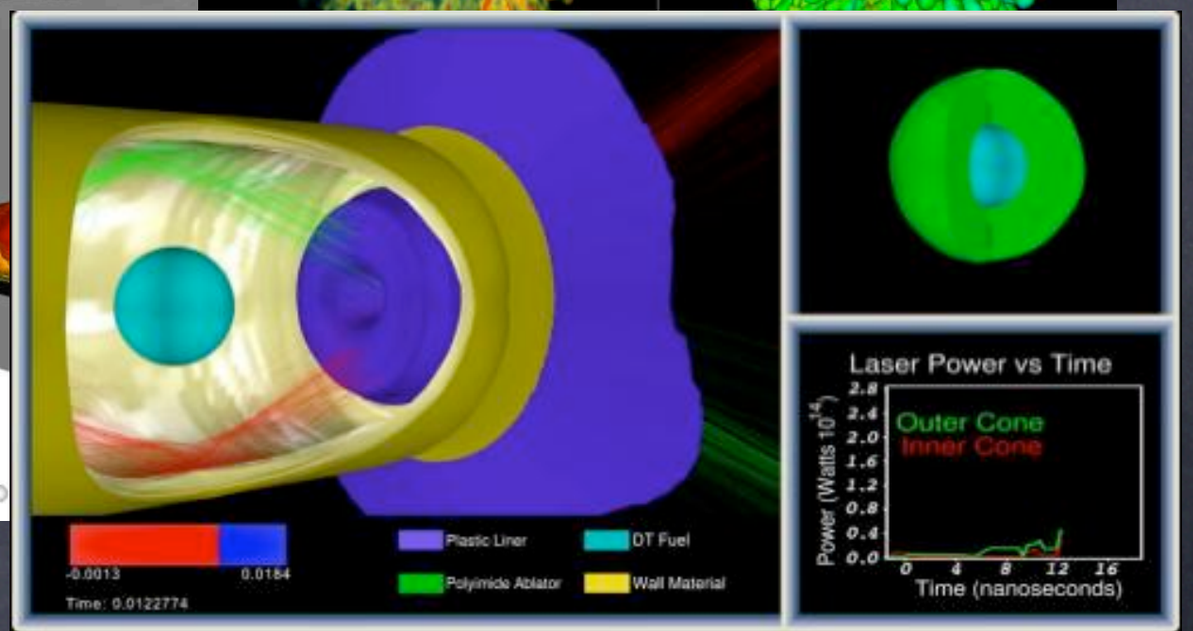



DB: HeatingCoil.cgns
Time:0
Pseudocolor
Var: Total_Pressure
304.5
205.1
105.7
6.250
-93.15
Max: 304.5
Min: -93.15
Mesh
Var: grid
Z
X
Y


DB: yf17.cgns
Time:0

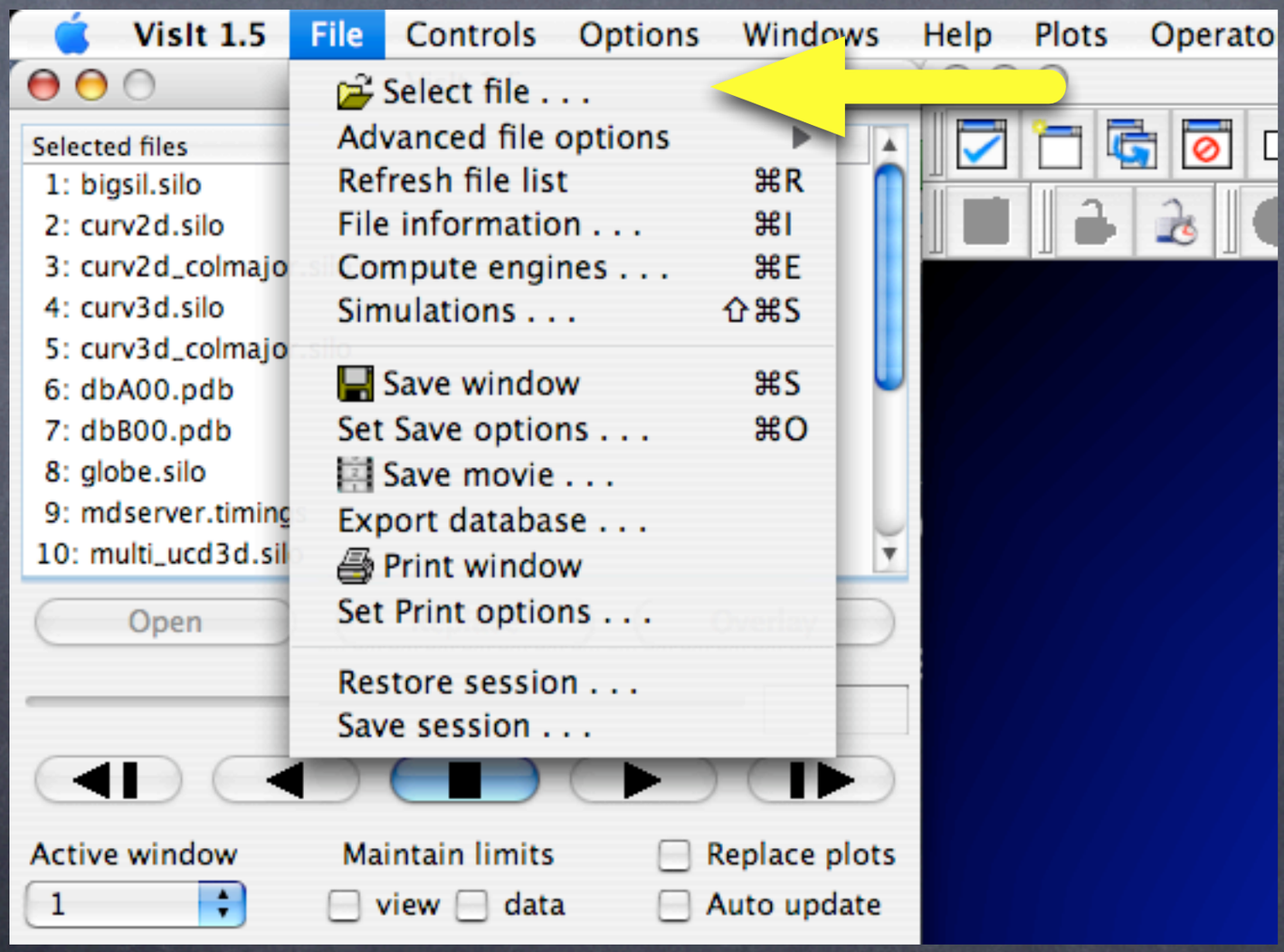

Mount St. He
Pseudocolor
Var: height
Units: degree
2543.
1612.
1147.
682.0
Max: 2543.
Min: 682.0
Z
X
Y




-0.0013
0.0184
Time: 0.0122774
Plastic Liner
DT Fuel
Polyimide Ablator
Wall Material
Laser Power vs Time
Outer Cone
Inner Cone
Power (Watts 10^14)
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
0
4
8
12
16
Time (nanoseconds)

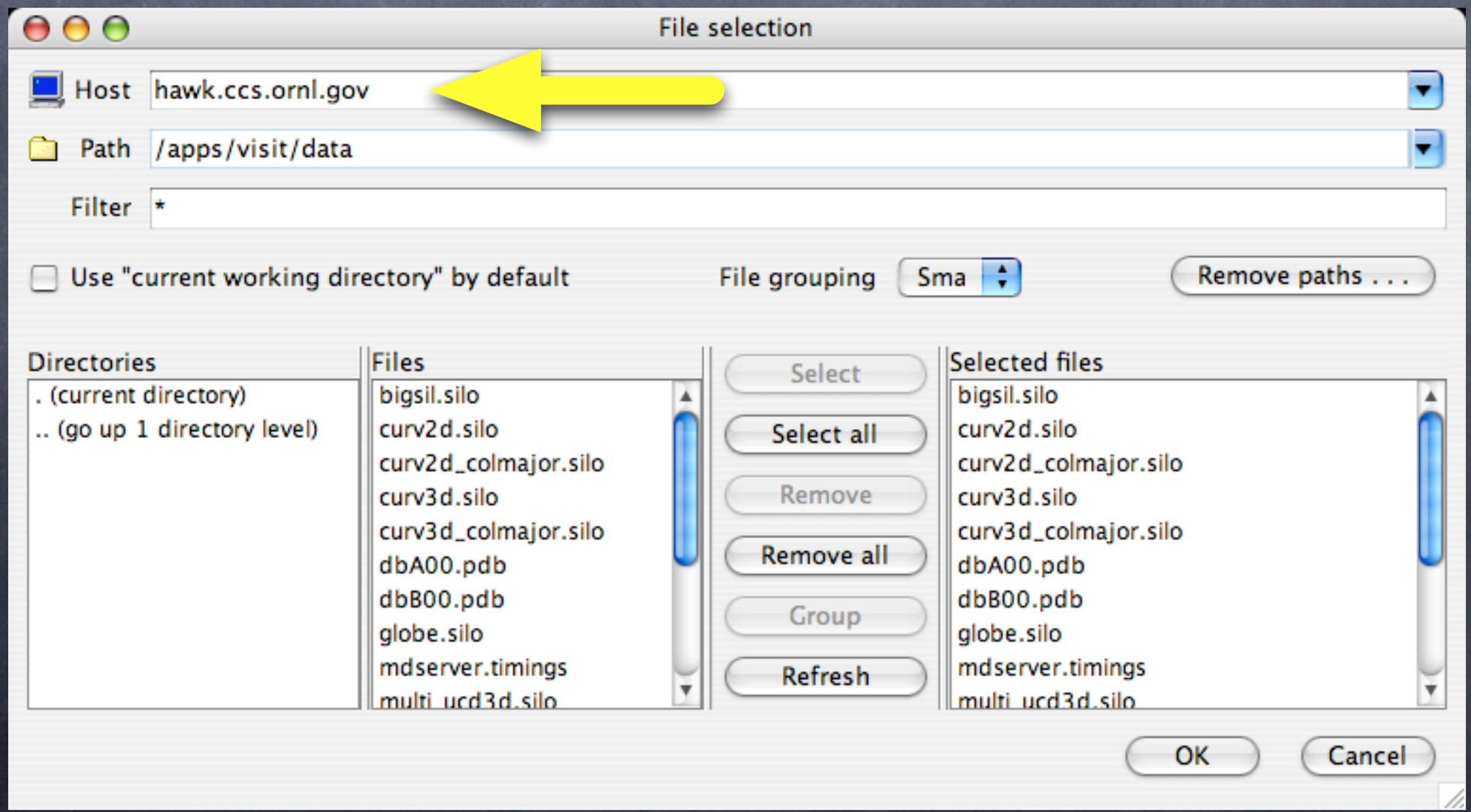
VisIt Startup

- Start VisIt client on your local machine
- Choose File->Select File..



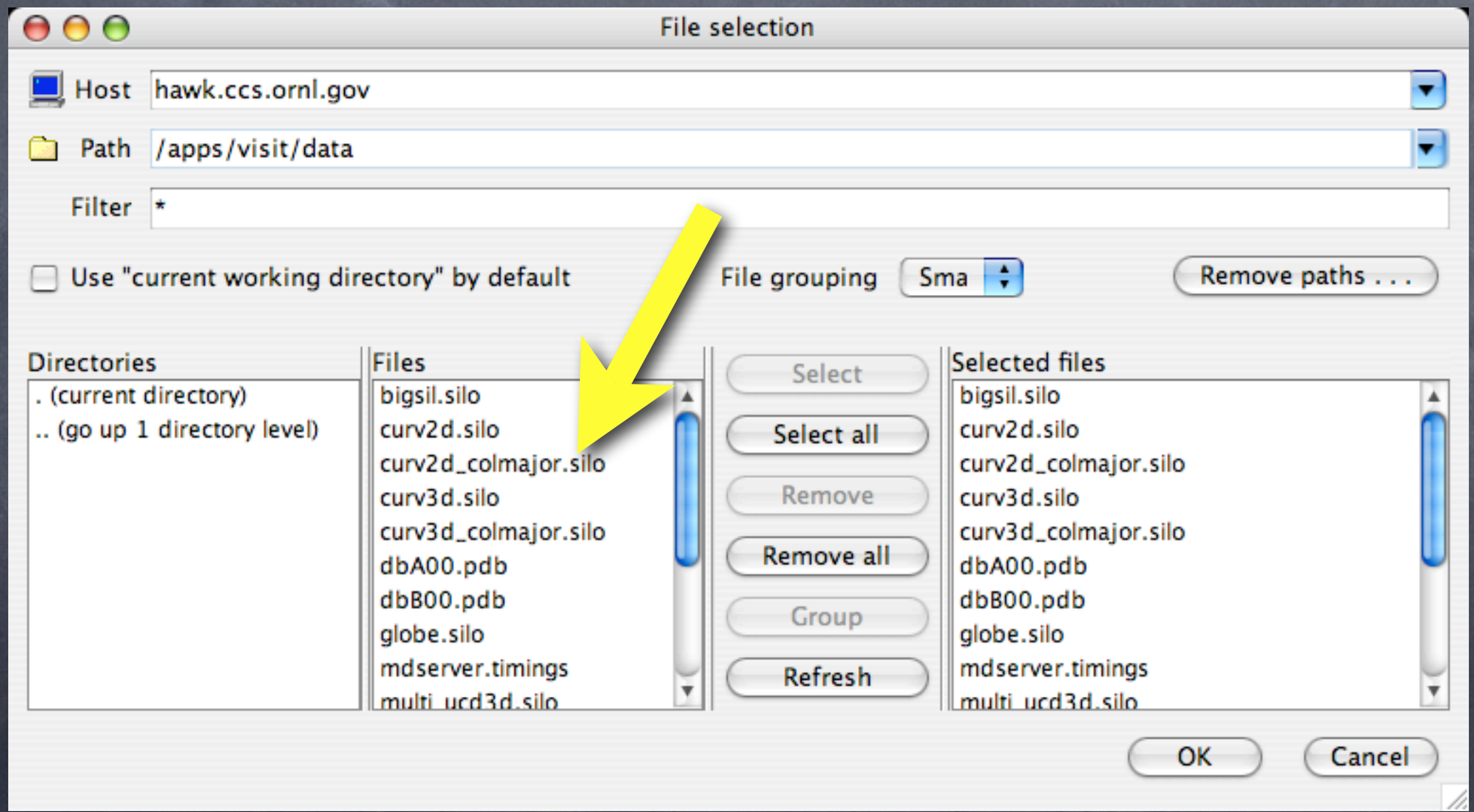
VisIt Startup

- Enter "hawk.ccs.ornl.gov" in the "Host" field, hit Return
- VisIt ssh's in shows you the files on hawk.



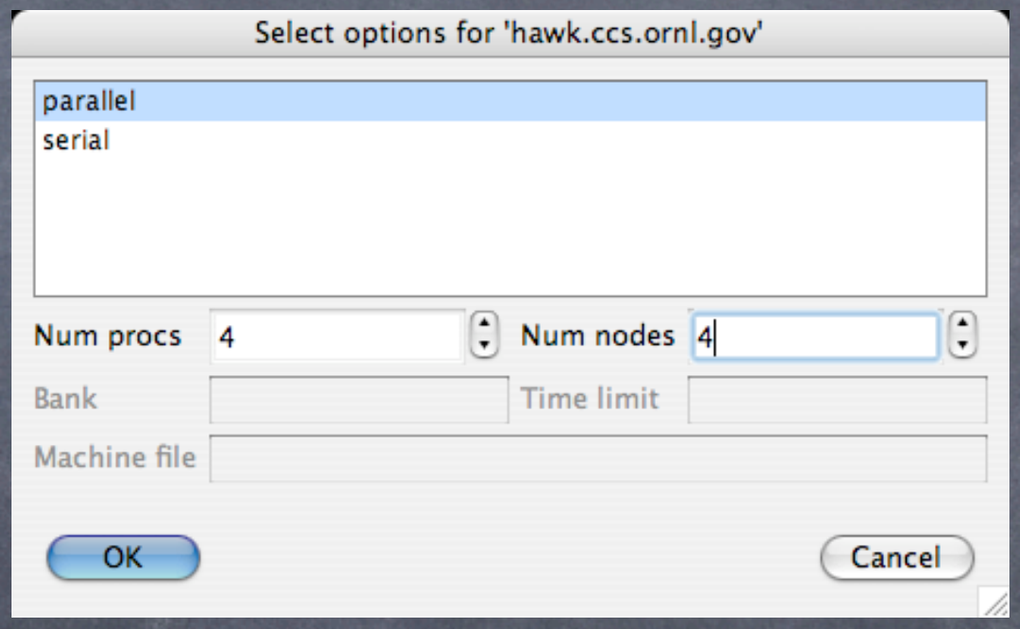
VisIt Startup

- Select the files you want to process and go!



VisIt Startup

- Once you open a file, VisIt will ask to start up a remote parallel engine
- Choose the number of processors/nodes.

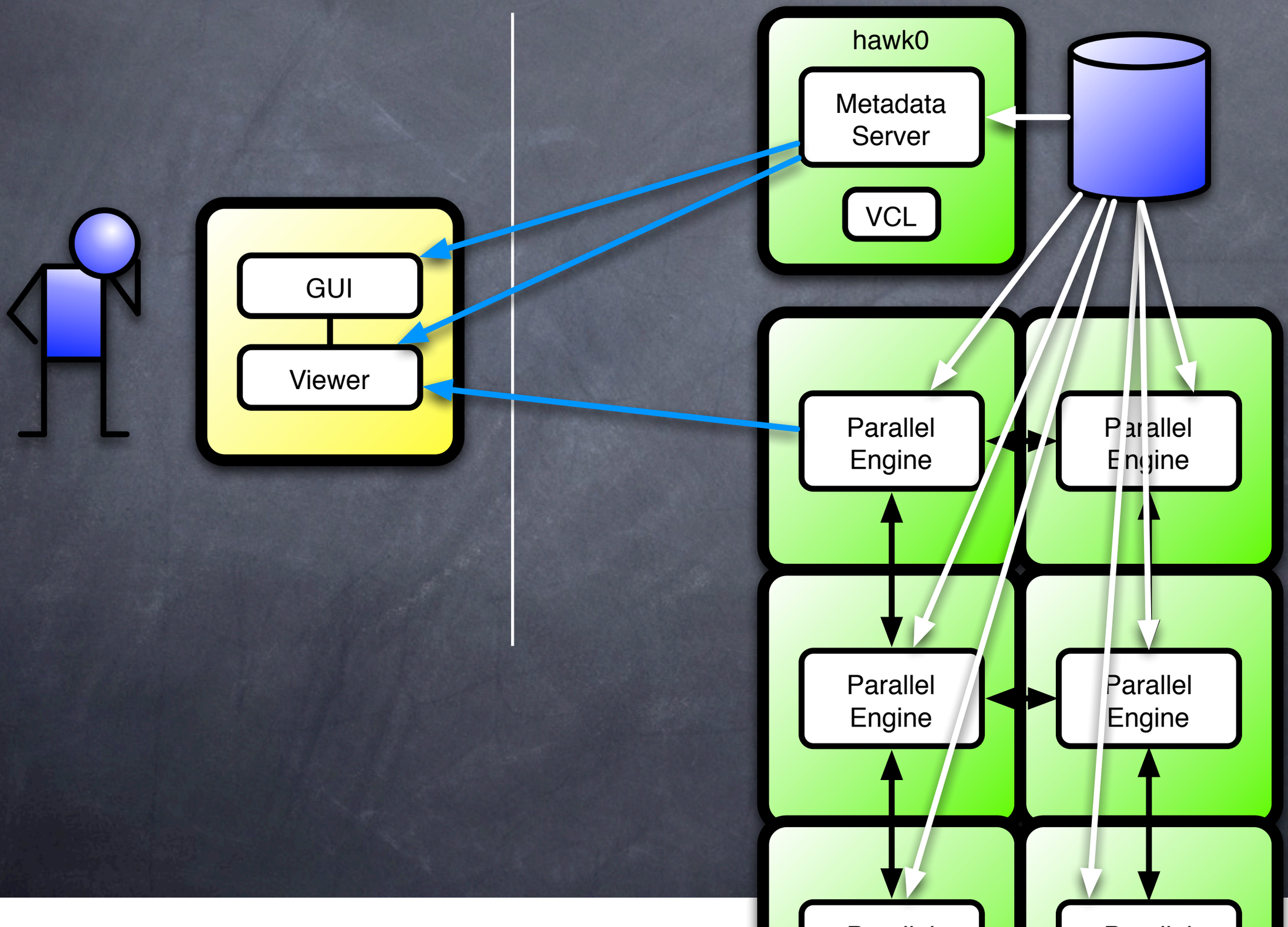


- VisIt interfaces with SLURM, sets up communication sockets, and data starts flowing.

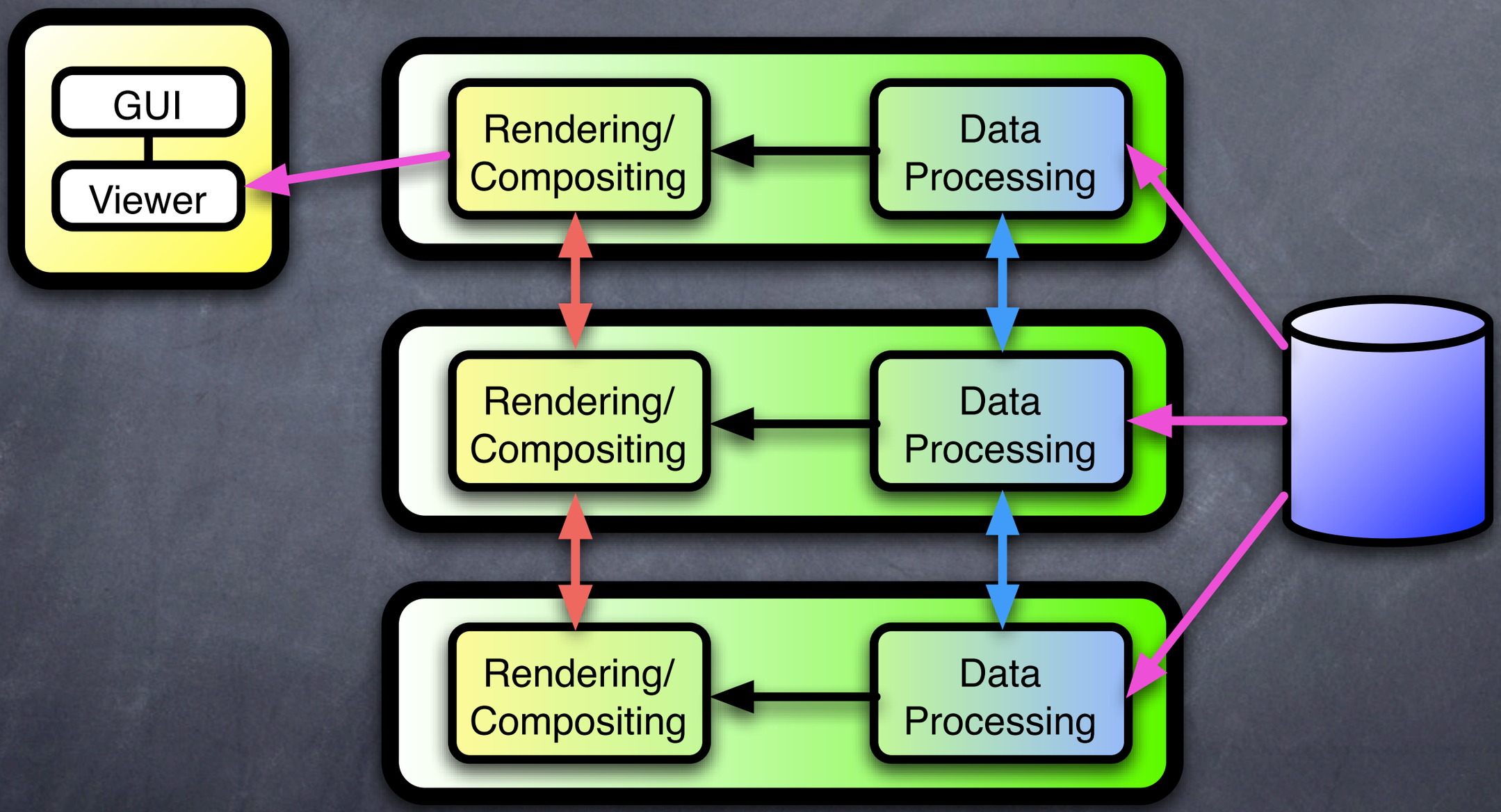
Configuring Remote Access

- All remote machine access is managed through "Host Profiles"
  - Serial/Parallel
  - Job submission process
  - Identification of ports
- You shouldn't have to mess with this...

Socket Initation



Data Flow


GUI
Viewer
Rendering/
Compositing
Data
Processing
Rendering/
Compositing
Data
Processing
Rendering/
Compositing
Data
Processing

VisIt demo

Paraview

Paraview

- Open Source. Funded by U.S. Department of Energy ASC DVS (The program formerly known as "ASCI VIEWS") program.
- The goal of the project is to develop scalable parallel processing tools with an emphasis on distributed memory implementations.

Paraview

- Built on top of the Visualization Toolkit (VTK). Uses VTK for its visualization algorithms and rendering.
- Paraview is written in C++ and wrapped in Tcl. Many parts of Paraview can be accessed through scripts or the command line.

Download Paraview

www.paraview.org

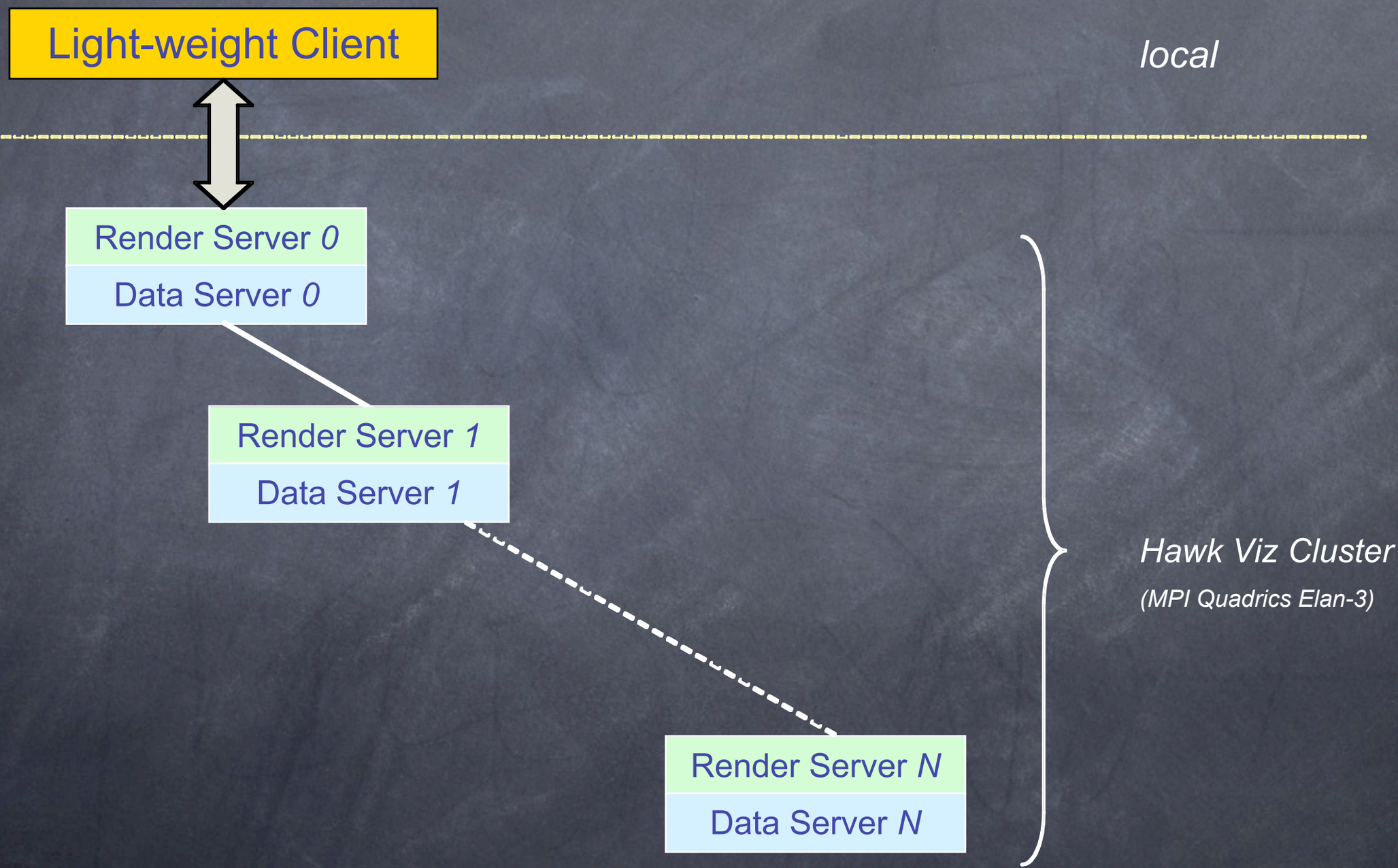
Linux(x86, glibx-2.3)

Windows

Macintosh OS X (X11)

Source

Paraview Data Flow



Launch client on local machine

```
local> pvclient -server-host=hawk51.ccs.ornl.gov
```

For reverse connection, launch the client before the server:

```
local> pvclient -rc
```

Configuring Paraview on EVEREST

From your local machine, ssh into hawk.ccs.ornl.gov. This is the visualization cluster login node

```
> ssh d65@hawk.ccs.ornl.gov

PASSCODE: **********
```

SLURM

Query SLURM for resource availability.

```
hawk0> sinfo

paraview_src/netcdf_mpi> sinfo
PARTITION AVAIL  TIMELIMIT NODES  STATE NODELIST
parallel*    up   12:00:00    40   idle hawk[1-43]
everest      up   infinite    14   idle hawk[51-64]
```

SLURM - Request Resources

```
hawk0> srun -p everest -N 14 -A
```

(see ‘man srun’)

SLURM – Verify Resource Allocation

```
hawk0> squeue
JOBID PARTITION NAME USER  ST TIME  NODES NODELIST
3086   everest      d65   R  0:03     14 hawk[51-64]
```

Load Paraview Module

```
hawk0> module avail

   ------- /apps/modulefiles/hawk -------

firefox/1.5      idl/6.1     idl/6.2

povray/3.6       cg/1.4.0-4  glut/3.6

chromium/1.2-32  glut/3.7    netcdf/
  3.6.0

chromium/1.7-32     idl/6.0

paraview/2.4-mpich
```

Load Paraview Module

```
hawk0> module load paraview/2.4-mpich

hawk0> module list
```

Currently Loaded Modulefiles:

1) paraview/2.4-mpich

Start X Servers on Allocated Nodes

```
hawk50> srun -jobid=3086 -N 14 xinit &
```

Server Startup

- Start Paraview data servers and render servers

```
hawk0> srun -jobid=3086 -N 14 pvserver &
Listen on port: 11111
Waiting for client...
```

- Paraview also allows reverse connections.

```
hawk0> srun -N14 env DISPLAY=localhost:
0.0 pvserver -rc --client-
host=160.91.43.90
```

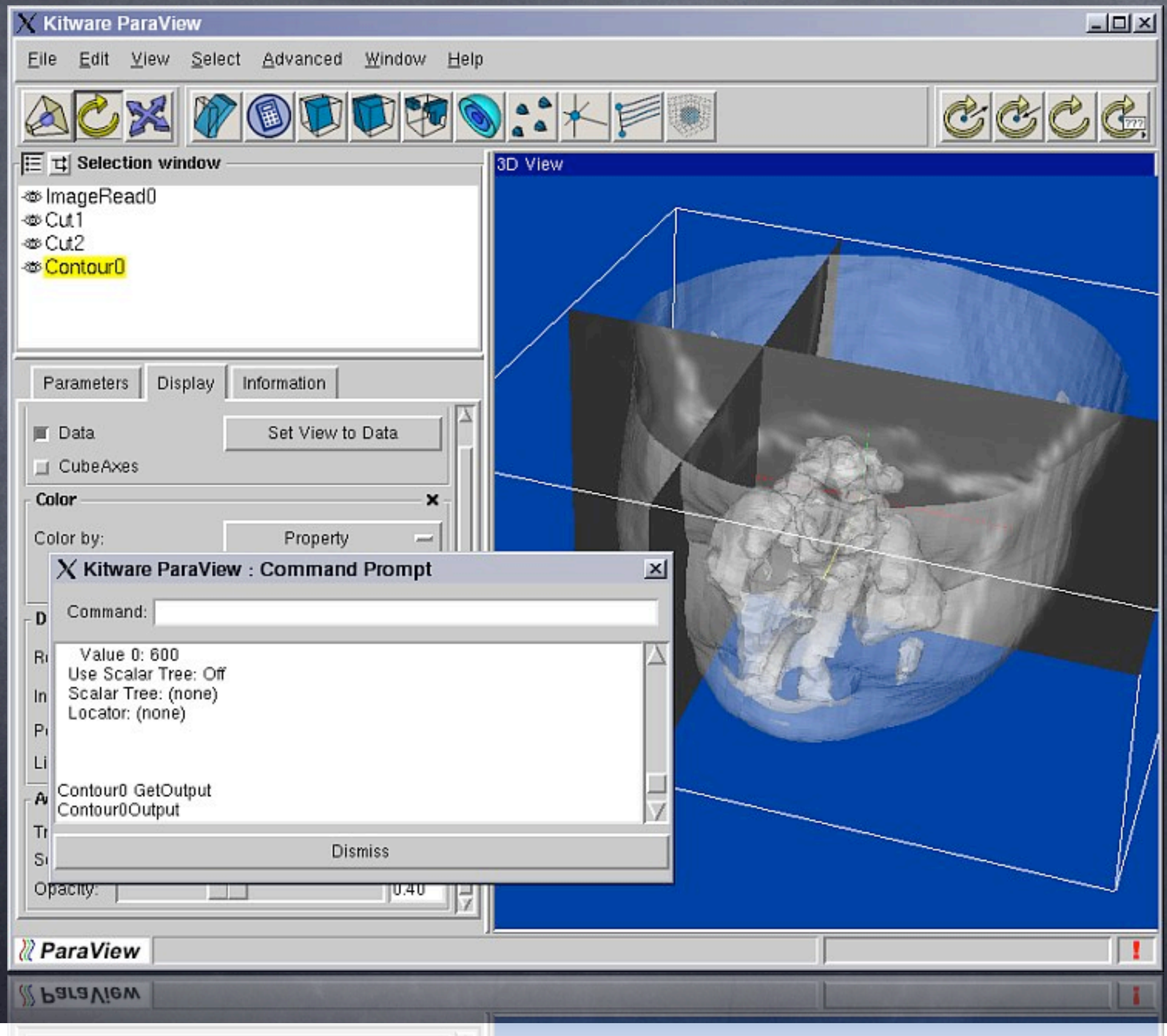
Paraview Visualization Pipeline

- Borrows visualization pipeline from VTK.
- Loading data and applying filters add stages to pipeline.
- VTK - access to many visualization algorithms.

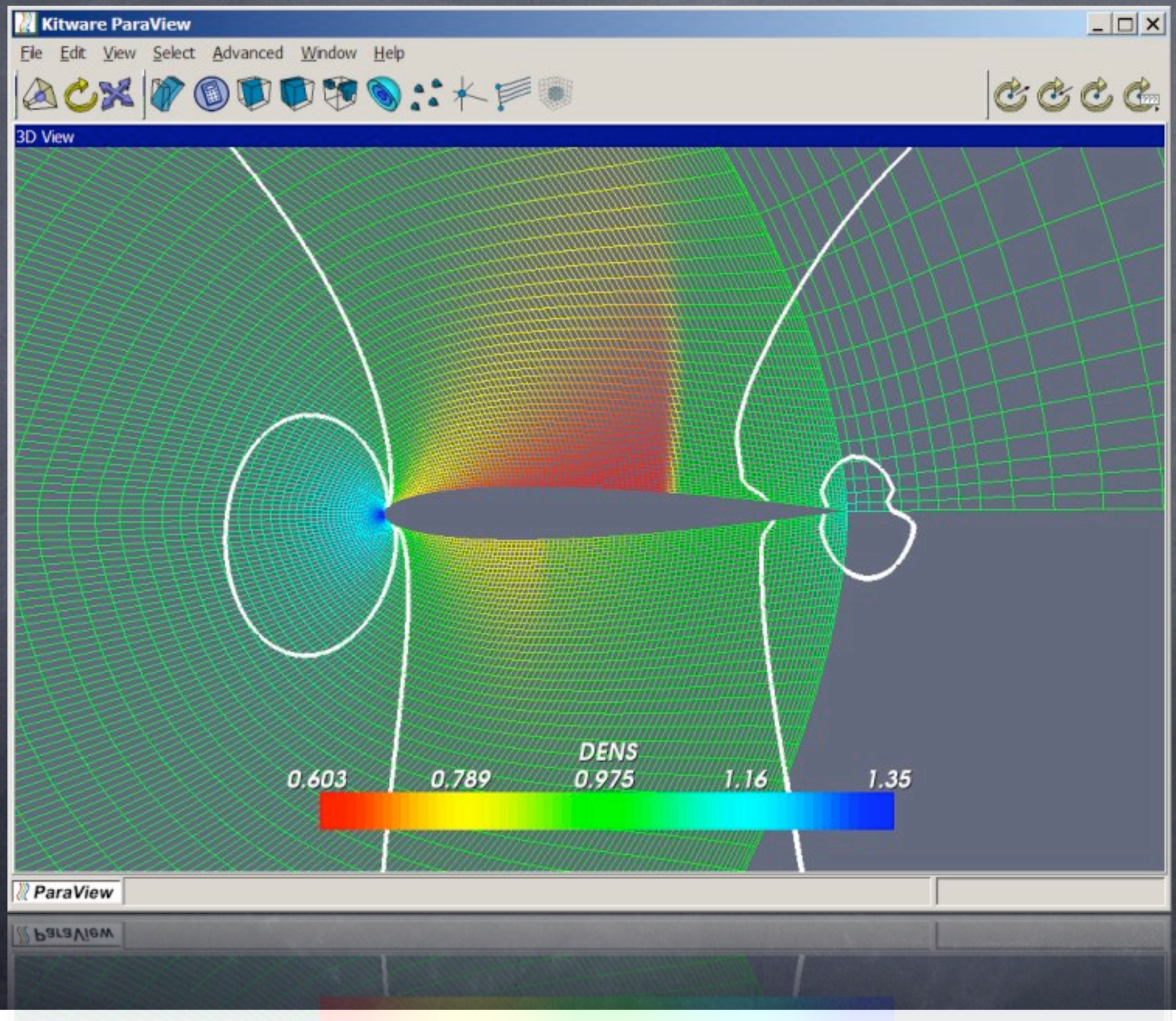
Modular Architecture

- The data processing, rendering, and user interface controls can be run in separate processes.

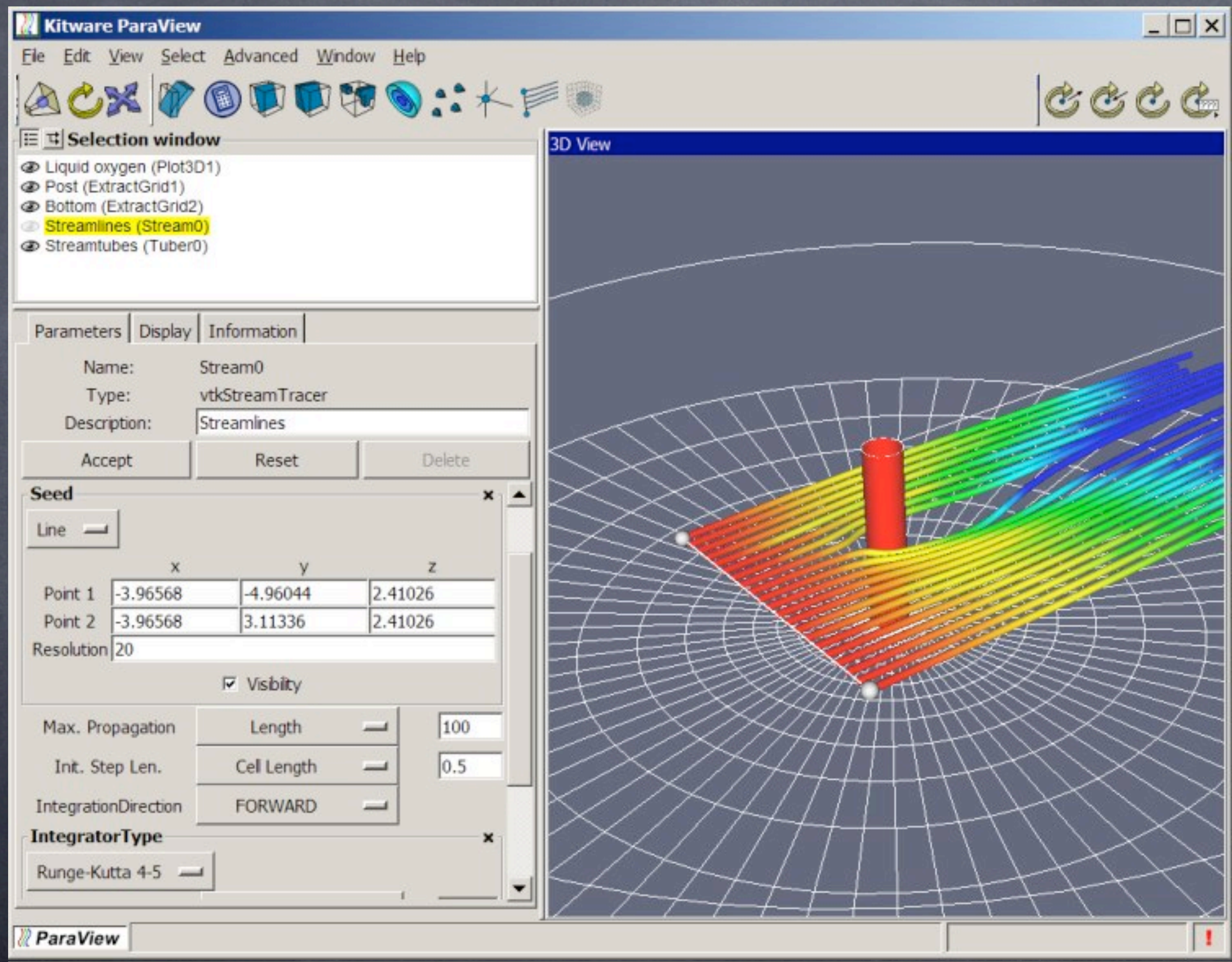
Isosurface and cutplanes of CT scan data



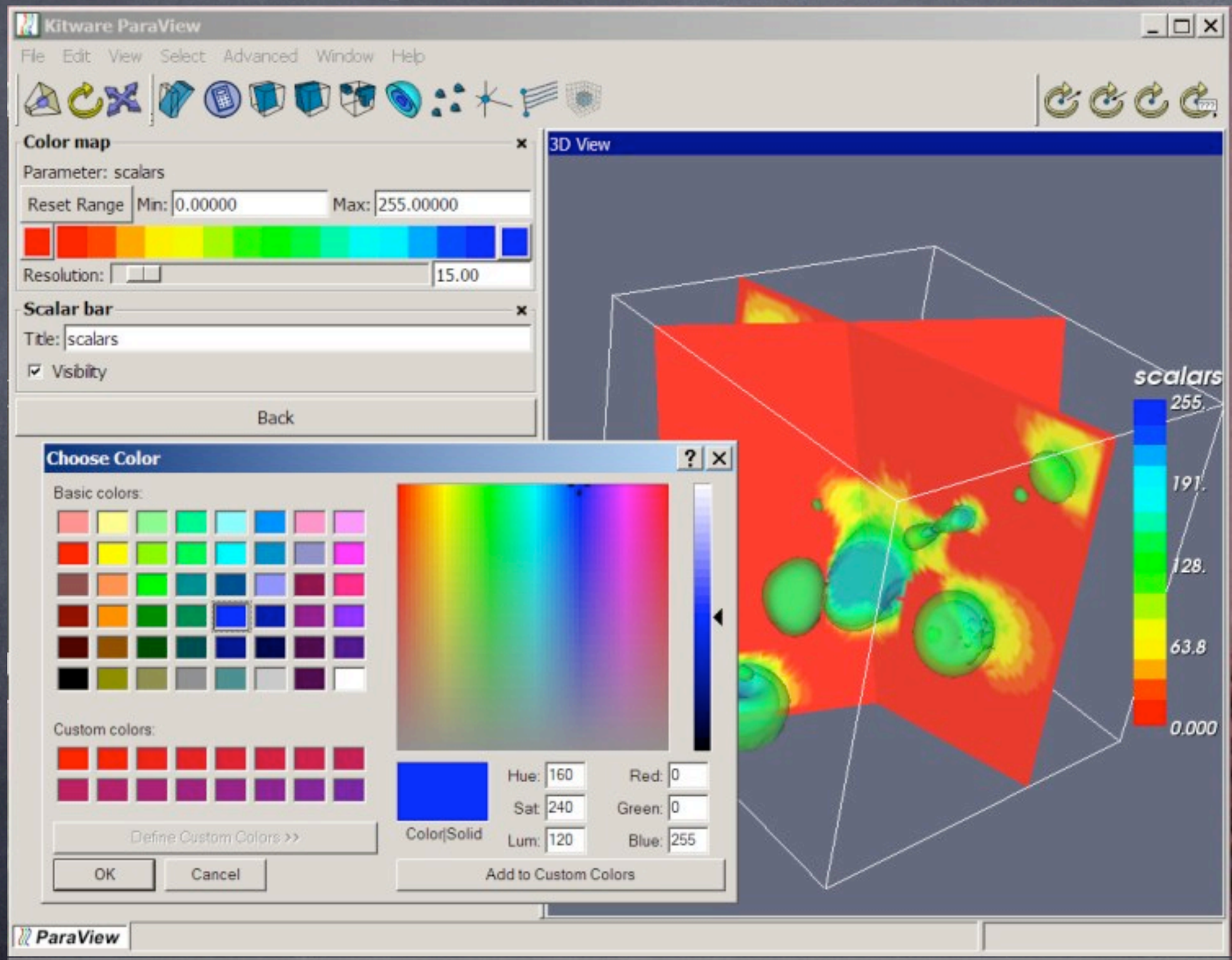
2D pressure isosurface. Multi-block curvilinear grid



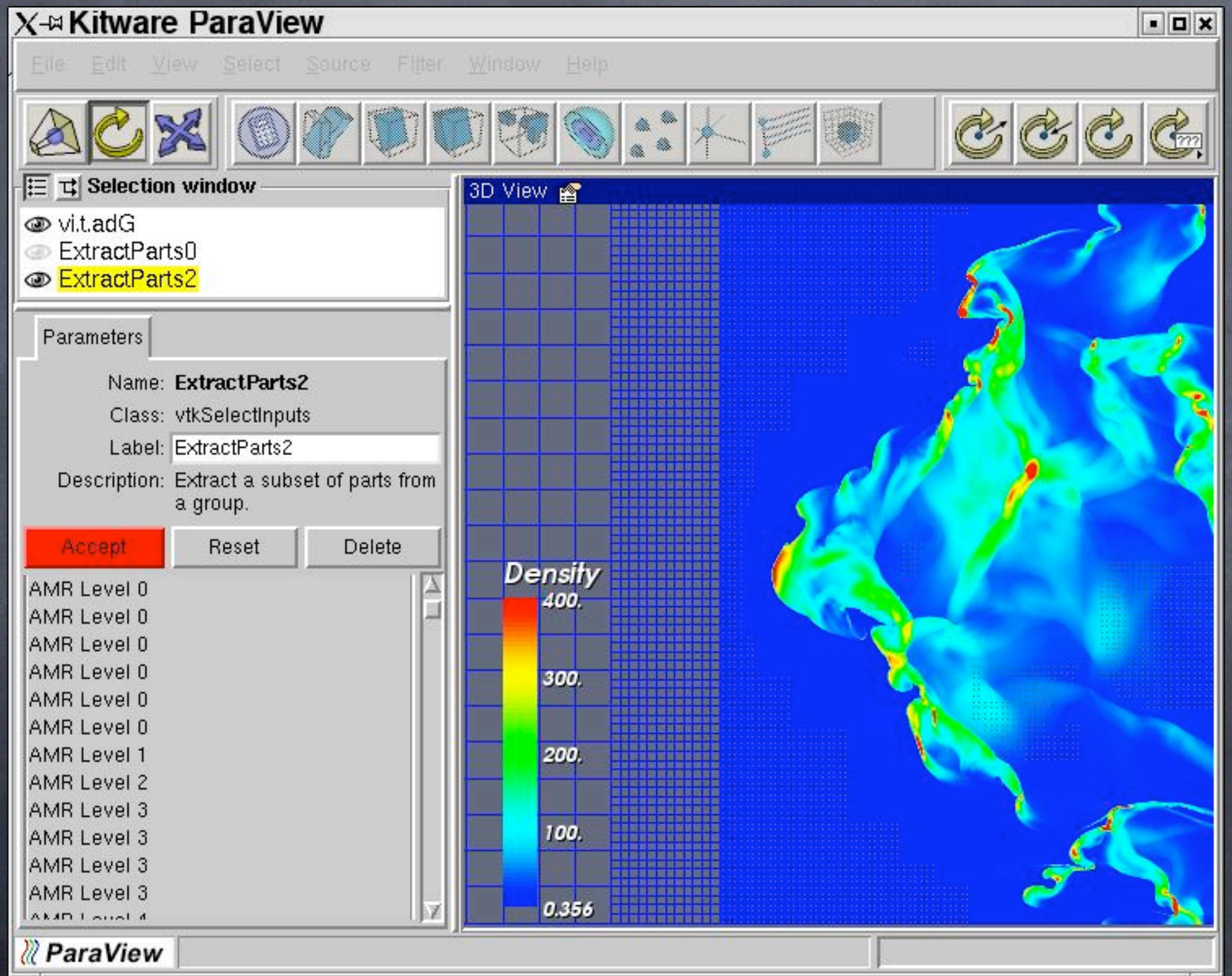
Liquid oxygen flow across a flat plate with a cylindrical post rising



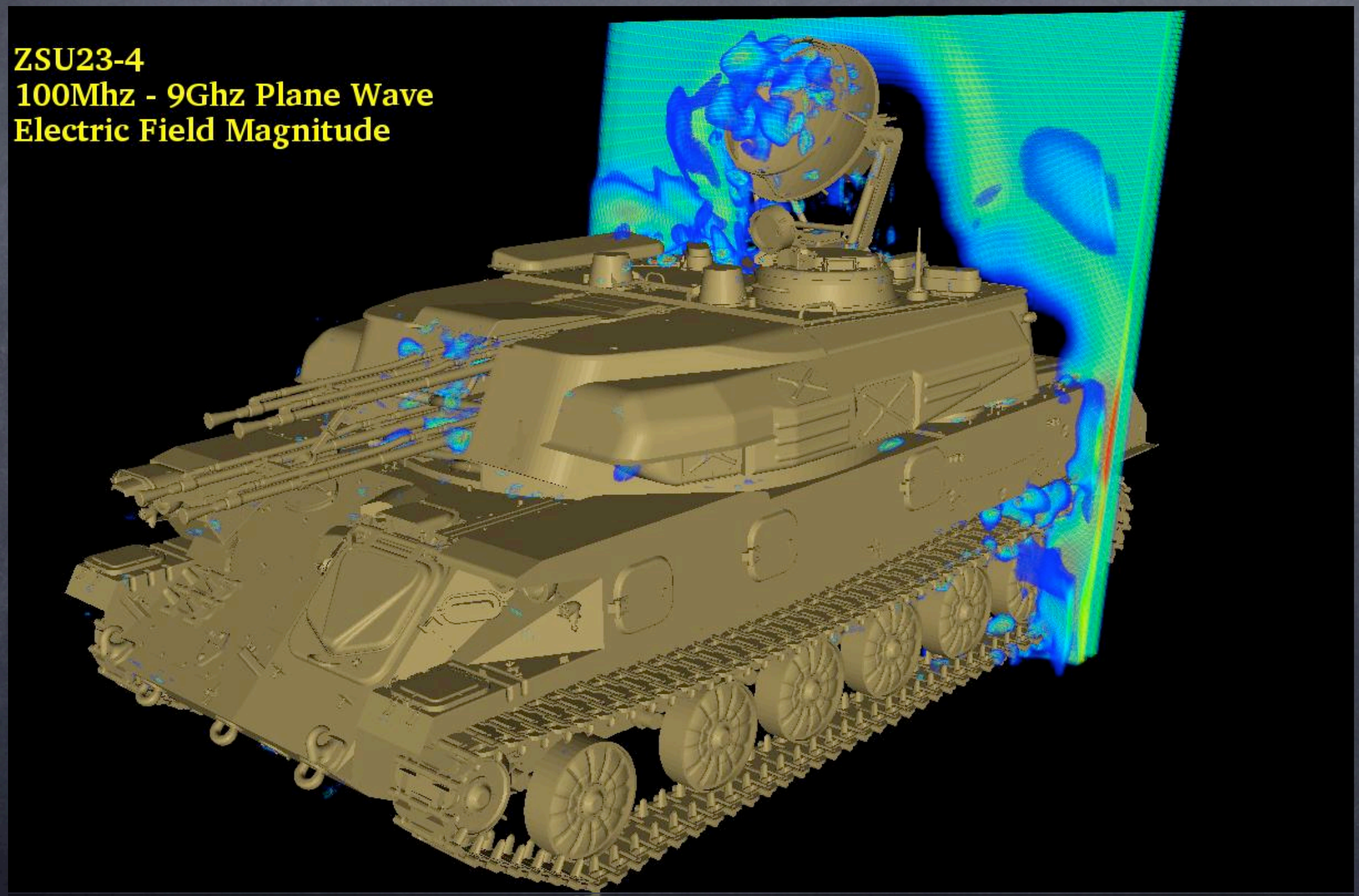
High potential wave function values around an iron protein molecule



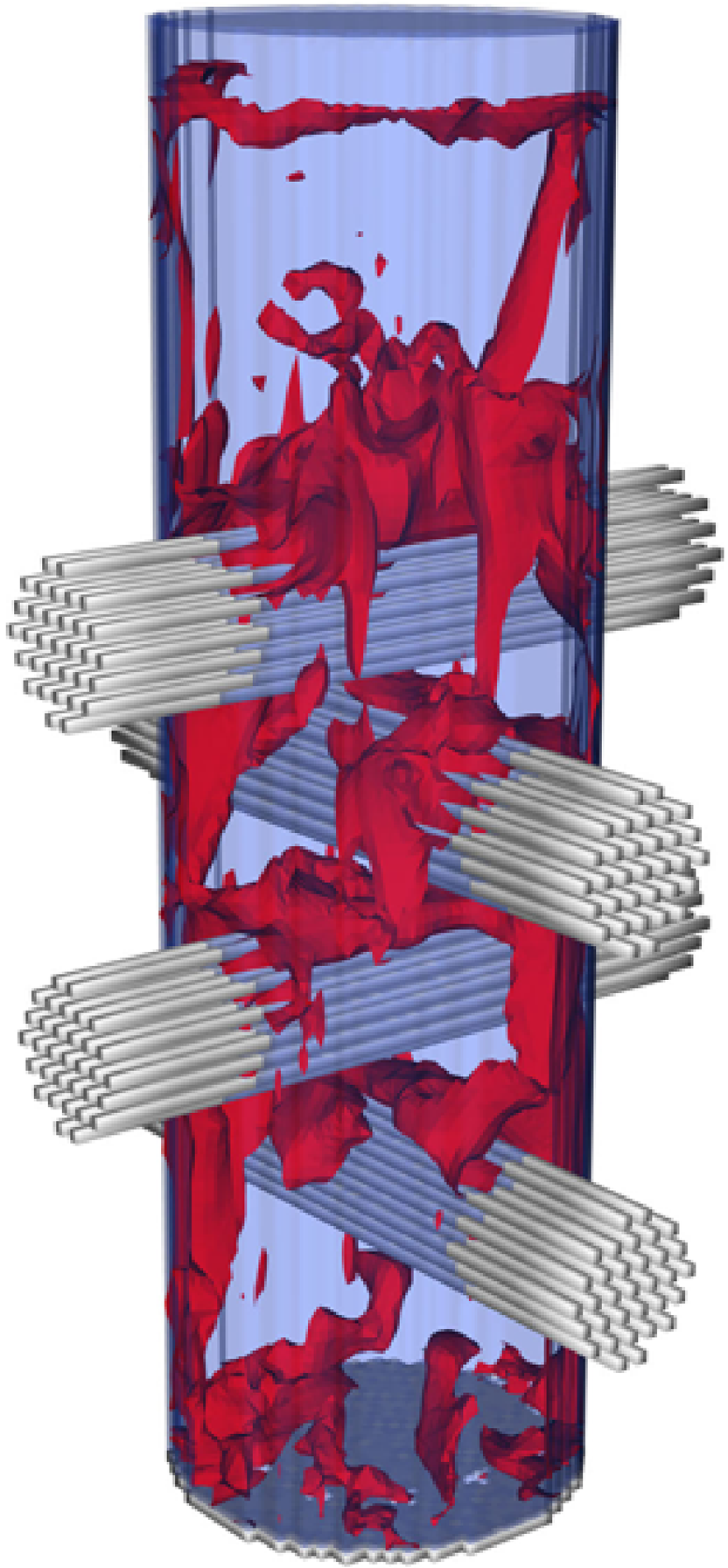
2D density (log-scale) in an AMR simulation of colliding winds by Rolf Walder and Doris Folini (Visualization by Jean M. Favre)

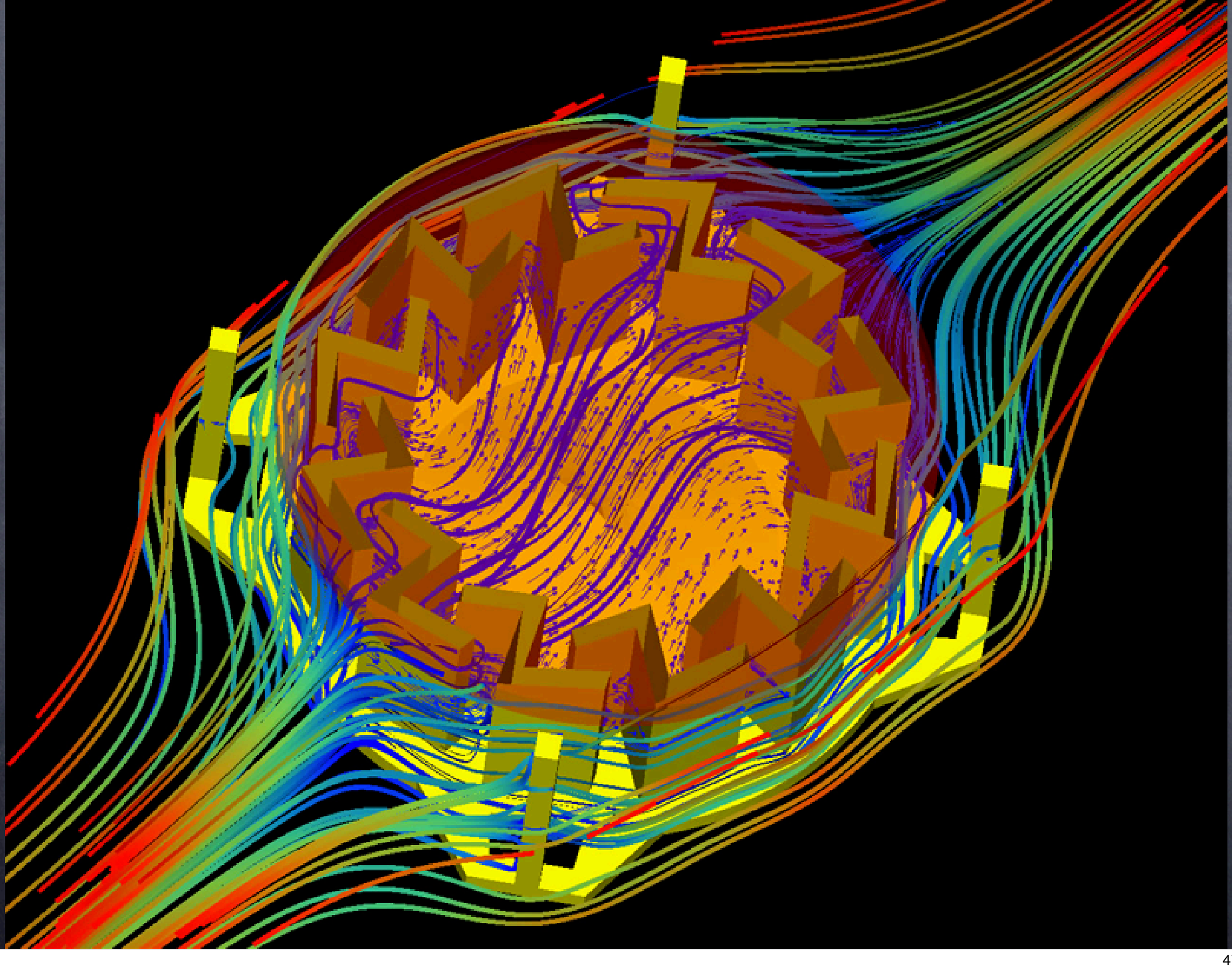


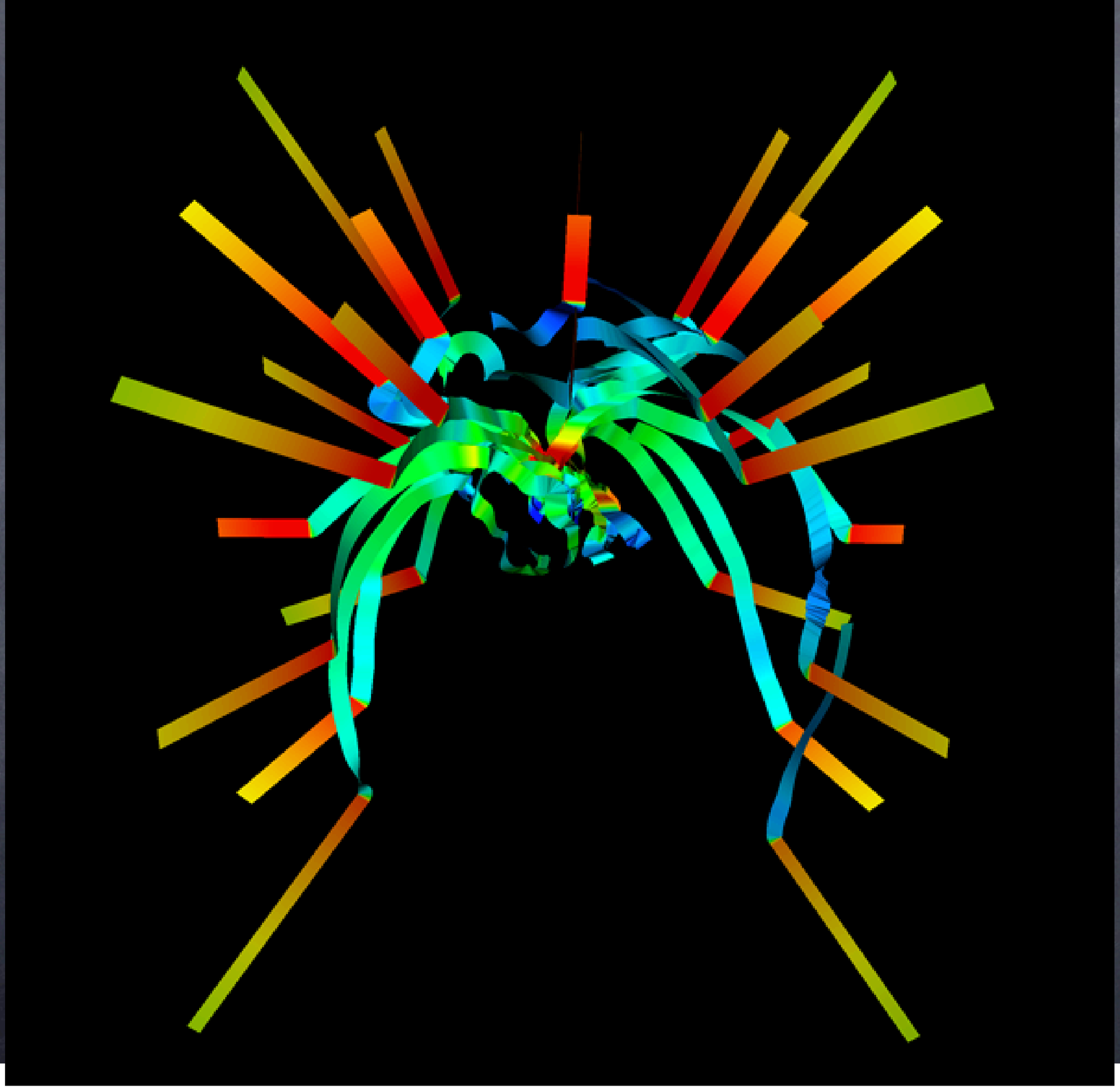
ZSU23-4 Russian Anti-Aircraft vehicle being hit by a planar wave. 2.5 billion cell calculation. Courtesy of Jerry Clarke (US Army Research Laboratory)



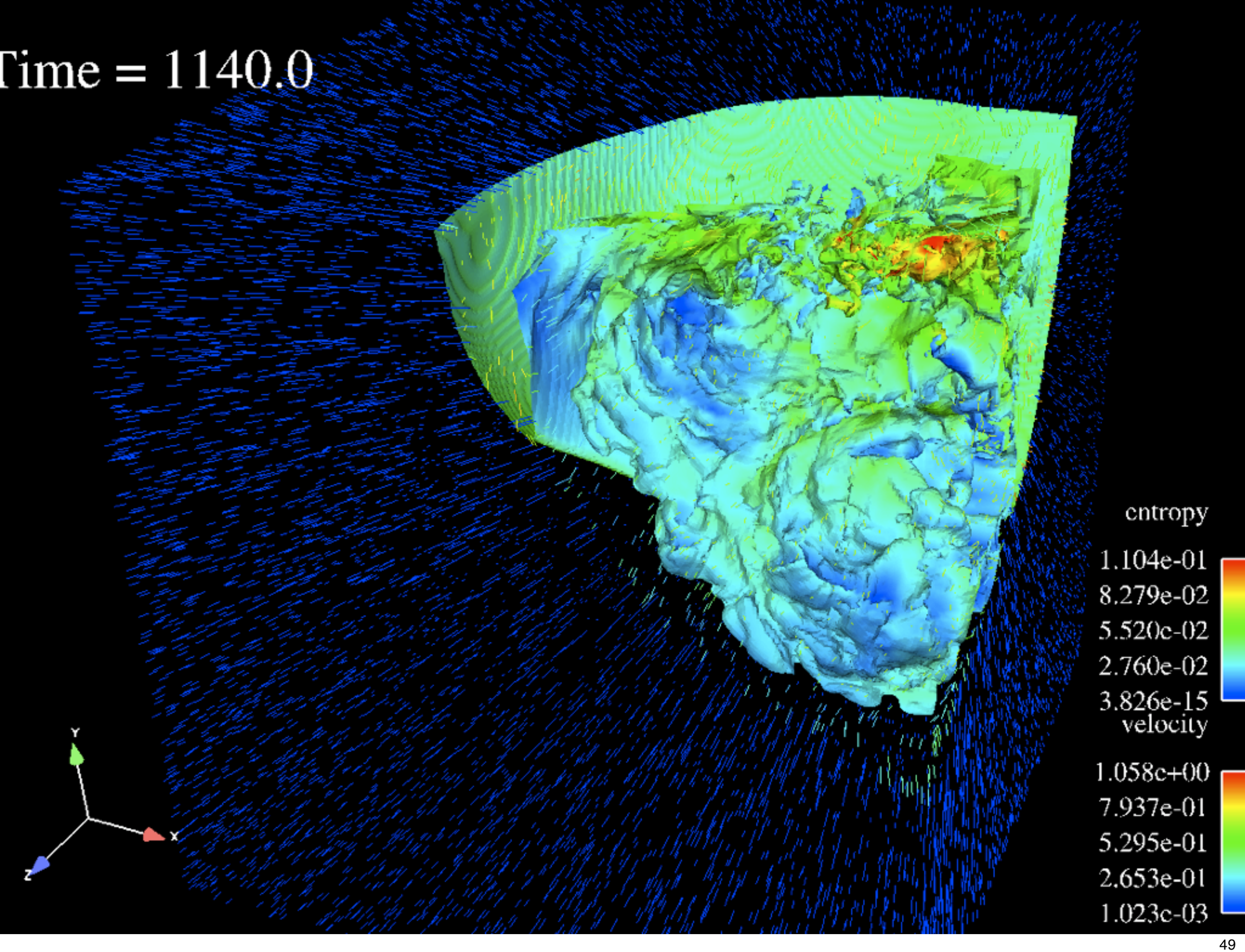
EnSight





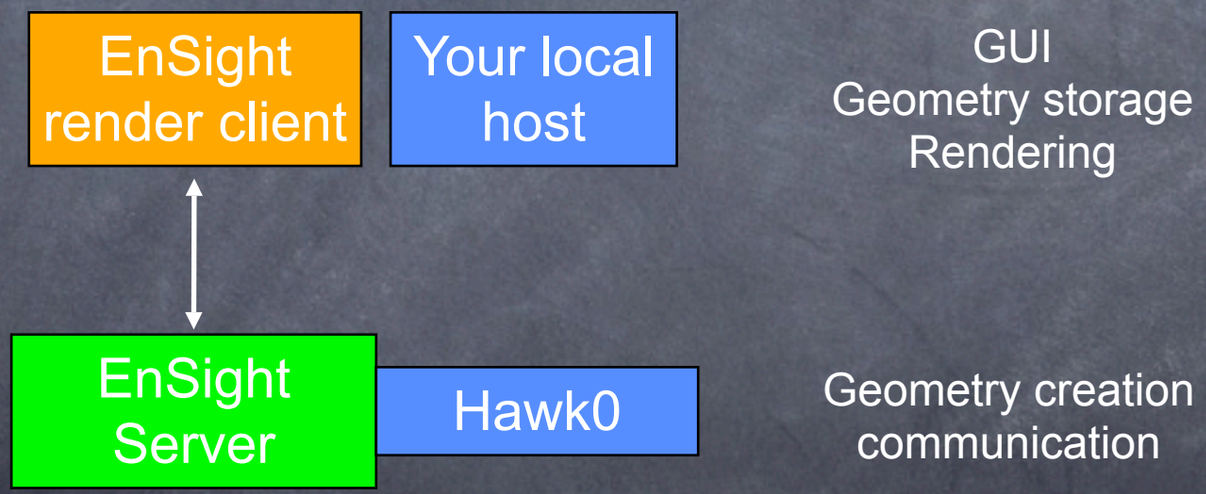


Time = 1140.0

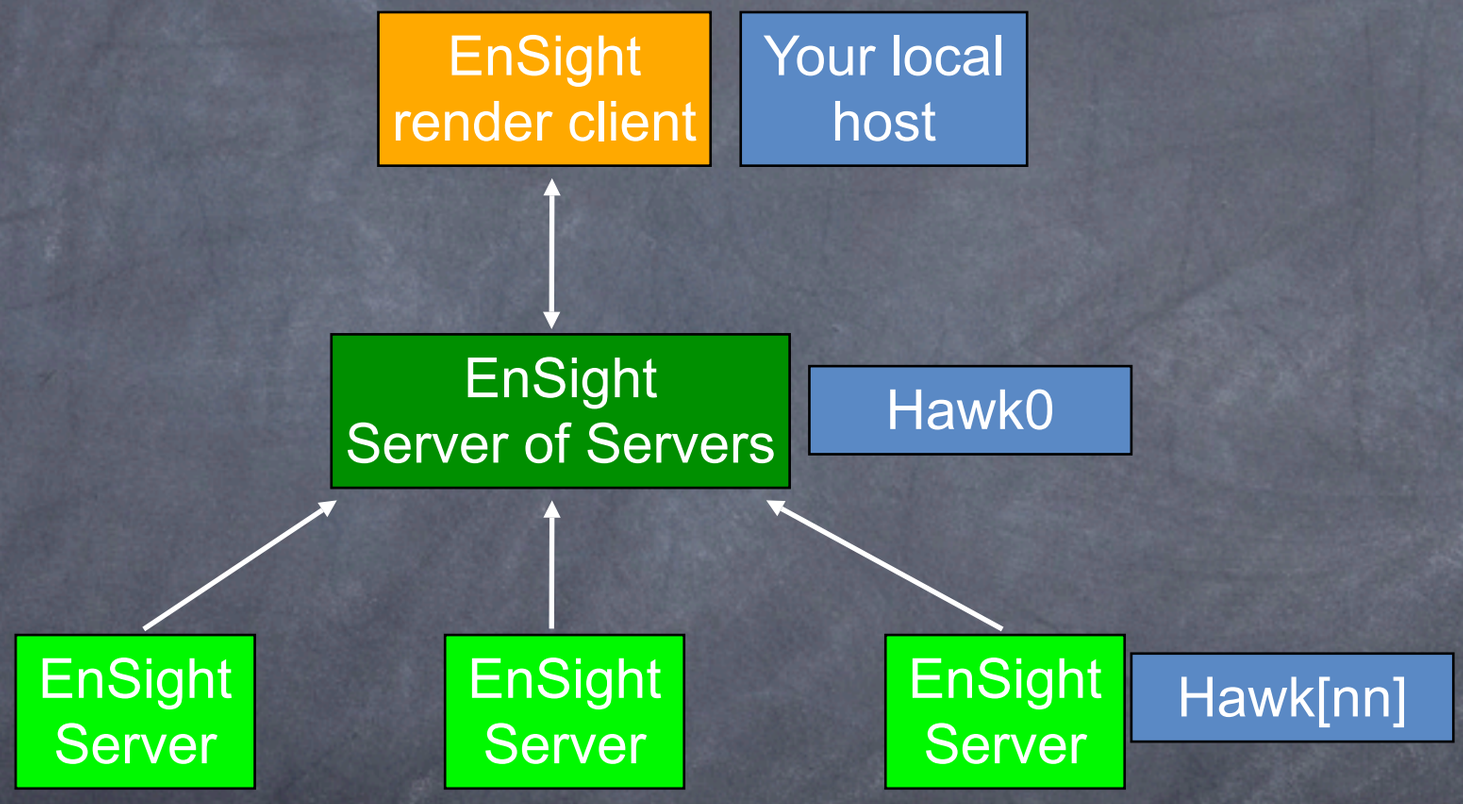

Y
X
Z
entropy
1.104e-01
8.279e-02
5.520e-02
2.760e-02
3.826e-15
velocity
1.058e+00
7.937e-01
5.295e-01
2.653e-01
1.023e-03

Basic Ensight Connection

1) VPN to ORNL using RSA fob
2) Launch client locally (`ensight8.client -cm`)
3) SSH into Hawk*
4) SLURM
5) Discover VPN IP name
6) Fire up server and point to client for connection
   (`ensight8.server -c` *`vpn_ip_name`*)



Distributed Ensight



EnSight

- Rich data model:
- Structured, unstructured, point, AMR, geometry
- Scalars, vectors, tensors, materials, species
- Many data input formats
- Less extensible, however better learning curve
- Collaboration through packaged geometry files

EnSight Demo